PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 4 : G07C 9/00

A1

(11) International Publication Number: WO 87/ 06378

(43) International Publication Date: 22 October 1987 (22.10.87)

(21) International Application Number: PCT/GB87/00262

(22) International Filing Date: 21 April 1987 (21.04.87)

(31) Priority Application Number: 8609620

(32) Priority Date: 19 April 1986 (19.04.86)

(33) Priority Country: GB

(71) Applicant *(for all designated States except US)*: IMAGE-PACK LIMITED [GB/GB]; Ludgate House, Fleet Street, London EC4A 2AB (GB).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)* : WHEATLEY, Richard [GB/GB]; 31a Earith Road, Willingham, Cambridgeshire CB4 5LS (GB). WHEATLEY, Malcolm, Robert, Henry [GB/GB]; 5 Old Court Hall House, Godmanchester, Huntingdon, Cambridgeshire PE18 8HS (GB). STOTEN, Philip, Anthony [GB/GB]; 19 Horselow Street, Potten, Bedfordshire (GB).

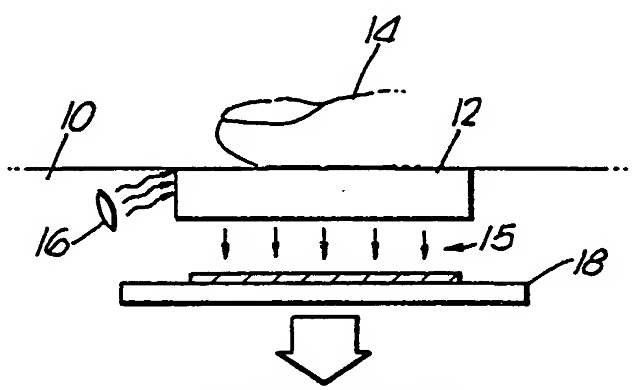
(74) Agent: GODSILL, John, Kenneth; Haseltine Lake & Co., Hazlitt House, 28 Southampton Buildings, Chancery Lane, London WC2A 1AT (GB).

(81) Designated States: AT (European patent), AU, BB, BE (European patent), BR, CH (European patent), DE (European patent), DK, FI, FR (European patent), GB, GB (European patent), HU, IT (European patent), JP, KP, KR, LK, LU (European patent), MC, NL (European patent), NO, RO, SE (European patent), SU, US.

Published

With international search report.

(54) Title: IDENTITY VERIFICATION



(57) Abstract

A fingerprint verification technique involves the derivation of data from a fingerprint in the form of an ordered set of values relating to the number of ridges (or troughs) measured orthogonal to a line across an area of the fingerprint, at each of a plurality of positions along the line. The data is derived using a semiconductor imaging sensor (18) consisting of a two-dimensional array of image sensing elements. Each line of the imaging sensor is read out as a varying DC voltage which is compared with a reference value in thresholding circuitry (42). The digital signal produced by the thresholding circuitry is used to clock a counter (44) to obtain for each row of the array a count of the ridges (or troughs) in that row of the array.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria
AU	Australia
BB	Barbados
BE	Belgium
BG	Bulgaria
BJ	Benin
BR	Brazil
CF	Central African Republic
CG	Congo
CH	Switzerland
CM	Cameroon
DE	Germany, Federal Republic of
DK	Denmark
FI	Finland
FR	France
GA	Gabon
GB	United Kingdom
HU	Hungary
IT	Italy
JP	Japan
KP	Democratic People's Republic of Korea
KR	Republic of Korea
LI	Liechtenstein
LK	Sri Lanka
LU	Luxembourg
MC	Monaco
MG	Madagascar
ML	Mali
MR	Mauritania
MW	Malawi
NL	Netherlands
NO	Norway
RO	Romania
SD	Sudan
SE	Sweden
SN	Senegal
SU	Soviet Union
TD	Chad
TG	Togo
US	United States of America

Title IDENTITY VERIFICATION

Field of the invention

This invention relates to identity verification and in particular concerns a method and apparatus for encoding and storing information relating to fingerprints and a method and apparatus for verifying the identity of a person.

Background of the invention

There are various circumstances in which it is important or desirable to be able to verify the identity of a person, for example for security reasons or in financial transactions to reduce or eliminate credit card and cheque card fraud.

Fingerprints constitute a unique characteristic of an individual and fingerprint comparison provides a good basis for identity verification that is widely used by bodies such as the police. However, visual comparison of fingerprints is a skilled task which cannot be performed reliably by untrained personnel.

There have been proposed several systems utilising fingerprint identification. Generally the prior proposals are concerned either with the improvement of a fingerprint image for visual comparison (for example see US 3,975,711) or with the production of characteristic data from a representation of a fingerprint. In the latter case, information from a fingerprint is obtained by scanning a fingertip or by providing an analogue or binary image of the fingertip. The image, or scanning output data, is processed to provide such characteristic data. In some prior proposals (for example US 4,210,899) the characteristic data is the minutiae of a fingertip, the minutiae being the ends and bifurcations of ridges of a fingerprint.

In another prior proposal (WO 82/03286) papillary line information is obtained by locating a reference point, defining several reading circles and sequentially deriving data from the reading circles to provide a bit sequence representative of a particular fingerprint.

There are two associated problems common to the above-mentioned systems, which to a large extent have hindered the commercial application of the systems on a wide scale. The first of these problems is the need to locate a reference point for data derived from the fingertip whose print is to be encoded. This is because such data must be capable of being stored and subsequently compared with similarly derived data for verification purposes. Even with the assistance of known mechanical and optical registering techniques, it is not possible to ensure that a subsequently positioned fingertip will be located in precisely the same position relative to a scanner or imaging device as when the data was originally derived. Therefore, a reference point must be found at each encoding and verification step, and this is not a trivial task for the characteristic data types referred to above. If no reference point is located, inaccuracies in use of the equipment will result.

The second problem lies in the type of characteristic data which is obtained. Such data involves a detailed analysis of an image of the fingerprint to determine such items as ridge depth, trough depth, ridge ends, position etc.. This coupled with the need for referencing, requires complex image production and signal processing equipment to the extent that the complexity and expense of such equipment constitutes a bar to commercial applicability in a wide sense. It is clear that, not only must the equipment for production and processing of the data be complex, but also that verification equipment for comparing stored data with newly derived data for identification purposes

suffers from the same problems. One attempt at simplification in respect of the second problem has been proposed in US 3,231,861, where data is derived from a scan of a single line across a fingertip. Such data includes the form of ridges and troughs, with their width, position and spacing. This proposal has stringent alignment requirements, and therefore is particularly prone to the first problem. A suggested solution in that case is the use of particular optical finger locating means for mechanical registration.

A further disadvantage arising from prior proposals is that in cases where, between data derivation steps, a fingerprint is scratched or otherwise damaged, the equipment has no facility to cope. In US 3,231,861 a rerun of the scan is suggested: in other cases the problem, which will inevitably occur is practice, is not addressed.

It is hence desirable to obviate or at least to mitigate the above-referenced problems in fingerprint identification.

It is also desirable to provide a method and apparatus enabling a fingerprint verification technique to be put into effect simply and relatively cheaply.

Summary of the invention

According to one aspect of the invention there is provided a method of obtaining information from a fingerprint characterised by deriving from an area of the fingerprint data relating to the number of ridges (or troughs), orthogonal to a line across the area, at each of a plurality of positions along the line.

By storing such derived data and comparing the stored data with similar data derived in similar manner from the corresponding fingerprint of a person, the identity of the person can be verified.

Hence, in a further aspect the present invention

provides a method of verifying the identity of a person by deriving data from their fingerprint in accordance with the method defined above comparing such data with similarly derived and previously stored data from the fingerprint to be compared; and indicating the result of the comparison step.

Preferably, a tolerance is provided such that, if the two sets of information correspond to within a prescribed degree of tolerance, the identity of the person is verified, and an appropriate indication, e.g. visual or audible, can be given.

It will be apparent that the invention is applicable to prints from any finger or thumb of a person. For brevity the term "fingerprint" is used to cover both fingerprints and thumb prints, and any other suitable characteristic skin configurations.

The present invention is based on the discovery by the present inventors that such number versus position information is sufficiently uniquely characteristic of a fingerprint to enable accurate verification to be carried out. As described below, in a preferred embodiment the information is obtained and stored as a ridge (or trough) count for each of plurality of extremely narrow strips extending substantially perpendicular to said line.

In that preferred embodiment, such information is derived as follows:

An image of the arrangement of ridges and troughs of a fingerprint is conveniently produced by use of a two-dimensional semiconductor imaging sensor array such as a charge coupled device or MOS imaging sensor. Such sensors comprise an array of image sensing elements (photosites) in which each photosite accumulates a charge which is directly proportional to the intensity of incident light. MOS imaging sensors are at present considered preferred since they can be manufactured more reliably than existing charge coupled device technology permits. Further, they have a simpler line read out

sequence more suited to application of the techniques of this embodiment of the present invention. The signal from the sensor is then processed by converting the charges into voltages and then applying voltage thresholding (with voltages above a particular value being treated as one and those at or below the value being treated as zero). The thresholded signal can be used to produce a binary image of the pattern of ridges (represented by ones) and troughs (represented by zeroes) from which the number information is derived, or can be used directly to produce number information.

Information representing the binary image, or the thresholded signal itself, is conveniently input to computer means such as a suitable microprocessor for derivation of information in a suitable form for storage.

A suitable signal can also be derived using other known fingerprint imaging techniques as in the prior proposals discussed earlier: the only restriction is that it must be possible to derive a count of the number of ridges (or troughs) in the relevant direction.

The present invention is particularly applicable to cases where storage space is limited and where it is not practicable to store a full representation of the binary image, i.e. an array of "ones" and "zeros". Thus, the information is stored in the form of an ordered set of counts hereinafter referred to as graphical data because it is capable of being represented as one or more graphs representing the variation in ridge (or trough) density with position. Such a graph can be obtained from an indication of the number of ridges (or troughs) in each row or column of the array by counting the number of transitions from zero to one for ridge count (or one to zero for trough count) within each row or column. This can be done by using the thresholded, binary signal for each row or column of the array to clock a counter actuatable on either the trailing or leading edges of the transitions.

The shape of such a graph has been found by the inventor, perhaps surprisingly, to be uniquely characteristic of a particular fingerprint. Using known statistical analysis techniques, the graph, or graphical data representative thereof, can be represented by various characteristic parameters derived therefrom, such as peak value, tri-quartile value, median value, quartile value etc of ridge (or trough) density or the area under the graph etc. Sufficient information to characterise the graph(s) (and hence fingerprint) to a desired degree is hence calculated, for example using suitable algorithms programmed into the computer. Subject to storage space limitations, it is appropriate to derive sufficient information to characterise a particular fingerprint and distinguish from all others, without being sensitive to normal variations in a particular print e.g. due to dirt or damage such as cuts. A suitable level of information and degree of correspondence in matching to produce a satisfactory working system can be determined experimentally.

The resulting information is converted into a suitable form for storage.

The information is preferably stored in machine-readable form, e.g. in magnetic form using conventional encoding techniques. For instance, the information may be encoded onto the magnetic stripe of a conventional credit card.

In use during verification, stored information relating to a fingerprint of a particular person is read in suitable manner, e.g. using a conventional magnetic reader in the case of magnetically stored information. Similar information relating to the corresponding fingerprint of the person whose identity is to be verified is obtained in similar manner to that in which the stored information was originally obtained. The two sets of information are compared, conveniently using computer means, and if they correspond to within a

prescribed degree of tolerance the identity of the person is verified and may be indicated in any appropriate manner.

The method should preferably be able to accommodate or compensate for variations in the positioning and orientation of the finger being examined during verification, as it is highly unlikely that a finger will be located in exactly the same position relative to image-producing equipment during both storage and verification steps. In embodiments using graphs or graphical data derived therefrom, as described above, variations in positioning and orientation can be accommodated by manipulating the comparable graphs using standard graph translation techniques, e.g. by suitable programming of computer means, until the graphs are aligned. For example, variations in positioning along the length of the finger can be accommodated by use of data relating to the area under a graph of ridge (or trough) density variations in the longitudinal direction with position across the width of the finger. Alignment can be effected by manipulating the measured graph using standard graph translation techniques until its integral (representing the area under the graph) matches that of the stored graph. Similarly, variations in positioning across the width of the finger can be accommodated by use of data relating to peak ridge (or trough) density, if necessary. To eliminate the need for comprehensive graph translation for comparison, means for mechanically registering a finger can also be provided.

The invention is applicable in a range of contexts, and lends itself well to use in verification of credit cards and cheque cards, with data conveniently being stored in magnetic form on the existing magnetic stripe of such cards. The existing stripes allow up to 107 bytes of data to be stored, and storage may be achieved using conventional encoding techniques. Data stored in this way may be read by conventional card reading

equipment.

It is also applicable to security systems for controlling entrance into a building, and for "clocking in" and "clocking out" of emplcyees. In the latter case, the clocking in device would include an imaging sensor and would only record the time of clocking in on production of a validation signal on comparing the data stored or the user's card and his fingerprint, to avoid one employee clocking in for several people by using their cards.

The invention also includes within its scope apparatus for use in the methods.

Hence, in a further aspect, there is provided apparatus for encoding information for obtaining information from a fingerprint characterised by:

means for deriving data relating to the number of ridges (or troughs) with respect to position along a dimension of the fingerprint.

The invention also provides apparatus for verifying the identity of a person as defined above and including means for comparing data so derived from a fingerprint of that person with data, similarly derived and previously stored, of the fingerprint to be compared; and means for indicating the result of the comparison.

For a better understanding of the present invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings which illustrate an embodiment for use as a credit card checker.

Brief description of the drawings:

Figure 1 illustrates schematically apparatus for receiving image data from a fingerprint for encoding onto the magnetic stripe of a credit card;

Figure 2 is a block diagram of circuitry used for production of density vs distance graphical data;

Figures 3b and 3c show the signals in the apparatus of Figure 2 in relation to a fingerprint pattern (Figure 3a);

Figure 4a illustrates schematically a sample thumbprint and Figures 4b and 4c show graphical information schematically representing data derived from a thumbprint but not necessarily corresponding to that of Figure 4a;

Figure 5 illustrates schematically credit card checker apparatus for verifying the identity of a person;

Figures 6a and 6b show two possible cases of vertical fingerprint misalignment during verification;

Figures 7a and 7b show two possible cases of horizontal fingerprint misalignment during verification;

Figures 8c and 8b show fingerprints and graphs for damaged or scratched fingerprints; and

Figures 9a to 9c are a side, end and plan view respective of a mechanical registration means for the apparatus of Figures 1 and 5.

Detailed description of the preferred embodiments

The apparatus illustrated in Figure 1 comprises a support 10 with a glass focusing plate 12 on which the pad of a finger 14, say the right hand thumb, of a person is located.

A light source 16 is located below the support 10, for side illumination of thumb 14 through plate 12. Reflected light 15 is directed to a semiconductor imaging sensor 18, such as a charge coupled device or MOS image sensor. Sensor 18 consists of a uniform two-dimensional array of image sensing elements (photosites), typically comprising 200 lines each with 250 photosites. When light falls onto such a photosite it accumulates a charge which is directly proportional to the intensity of the incident light. In use, the sensor 18 will thus build-up an image representative of the arrangement of ridges and troughs of the illuminated thumbprint.

After an integration period, during which an image

of the fingerprint will be built up within the photosites of the imaging sensor 18, each line of the imaging sensor is read out as varying DC voltage. Figure 3b gives a typical example of an output signal from the sensor for the fingerprint variation of Figure 3a. The voltage varies, depending on whether a fingerprint ridge or trough was picked up by each of the photosites within that line of the sensor array.

Figure 2 illustrates a system for converting the video signal (Figure 3b) into a ridge-count (i.e. a count of the number of fingerprint ridges present in that line of the sensor array). The signal varies quite uniformly around a central value which is the median between the voltage at the centre of a ridge and that at the centre of a trough. Using thresholding circuitry 42, the video signal is converted into a digital signal (shown in Figure 3c), which is used to clock a counter 44. The thresholding circuitry is conventional, and essentially determines whether the video signal level is above or below a given value. By using the rising edge of the digital signal from the thresholding circuitry 42, the counter value will give a count of the number of ridges within that particular line of the sensor's array.

Timing control circuitry 46 for the imaging sensor indicates that a complete line of the sensor's image has been output. This signals, via an interrupt port, a microprocessor 48 to read the current value of the counter 44 and then to reset the counter 44 ready to acquire the ridge-count for the next line of the sensor array. By acquiring the ridge-count for each line of the sensor array a ridge-density graph of the form shown in Figure 4b, that is in the form of an array of ridge-counts with respect to position across the fingerprint can be built up. The shape of this graph is unique for every fingerprint and can therefore be used to encode a representation of the fingerprint onto the magnetic strip of a plastic card for verification of a person's

identity at a later date using the same principle. If further characterising information of the fingerprint is required, a further graph representing ridge density variation lengthwise of the fingerprint may be generated, as shown in the graph of Figure 4c, and information characterising that graph could also be stored on the credit card.

While it would be possible to process the sensor image to provide a binary matrix of ones and zeroes for ridges and troughs, the limitation on data storage space available on the magnetic stripe using such standard encoding rules out the storage of such a matrix: the current standard used for encoding data onto the magnetic stripes of credit cards (International Standard Organization standard 3) allows up to 107 bytes of data to be stored on a standard magnetic stripe. However, the production and storage of a complete matrix may be appropriate in some circumstances.

The shape of graph of Figure 4b is far simpler to process than a vast array of binary data. With an imaging sensor comprising 200 rows each containing 250 photosites, this will give an accurate graph for a typical thumbprint which has up to 50 ridges horizontally and vertically.

Due to the limited amount of storage available on the magnetic stripes, it may not be appropriate to store the ridge density graph in its entirety.

In this case, the data can be compressed as follows:

The points a through g on the horizontal axis of the graph of Figure 4b are seven points which could be used to characterise the ridge density graph. Point d corresponds to the line number within the sensor array at which the maximum ridge count to both sides of the peak value were found. Similarly b and f are at half of the maximum ridge count and a and g are at a quarter of the maximum ridge count.

Values to both sides of the peak are calculated since it is highly unlikely that the graph will be symmetrical.

From the seven points a through g characterising values can be calculated to characterise the shape of the graph as follows:

1. The number of sensor array lines between points a and b.
2. The number of sensor array lines between points b and c.
3. The number of sensor array lines between points c and d.
4. The number of sensor array lines between points d and e.
5. The number of sensor array lines between points e and f.
6. The number of sensor array lines between points f and g.

Two other values which may be required are the actual peak ridge count and the area under the curve above the quarter peak ridge count: these two values will be used as described later when adjusting the graph obtained from the card bearer's fingerprint for verification.

To minimise the amount of storage required for these eight characteristics, the values are stored as binary coded hexadecimal numbers using Track 1 on the card's magnetic stripe (this is because the American National Standards Institution specification only allows the storage of numeric characters on Track 2).

Each of the six characteristic values can be stored as a two character hexadecimal number which allows such characteristic values up to 255 (hexadecimal FF). The peak ridge count characteristic is again stored as a two character hexadecimal number, allowing a peak count

up to 255. The integral under the graph is stored as a four character hexadecimal number, giving a maximum value of 65535 (hexadecimal FFFF).

Using the above method, the graph characteristics are stored using only 18 characters on track 1 which still leaves sufficient storage space for additional data if it is determined in any particular case that using seven points a through g along the horizontal axis of the graph is insufficient for the required level of accuracy.

Figure 5 illustrates credit card checker apparatus as used at a point of sale (or entrance into a building for example) for verifying the identity of a user by deriving information from the corresponding thumbprint of the user and checking it against information stored on the magnetic stripe of the user's card.

The apparatus comprises a thumbprint reader apparatus corresponding to the apparatus of Figure 1 and comprising a support 20, glass focusing plate 22, light source 24 and semiconductor imaging sensor 26. A representation of the fingerprint of the user's right thumb 28 is produced in exactly the same way as described in connection with Figure 1, and the information is fed via interface bus 30 to a control unit 32. The apparatus further comprises a conventional card reader 34 arranged to read information stored on the magnetic stripe 36 of credit card 38 in conventional manner. Encoded data read by reader 34 is also fed via interface bus 30 to control unit 32.

When a person presents a card, he/she will be required to place a finger onto the glass plate 22 and a ridge density graph will be acquired as previously detailed. The encoded data will also be read from the magnetic stripe of the card. The control unit 32 will then compare the newly acquired graphical data against that read from the card, using conventional comparison techniques.

The data stored on the plastic card represents

that section of the encoded ridge density graph which is above the quarter peak ridge count line on the graph constructed for encoding onto the card. For this reason, the newly acquired graph is adjusted vertically so that the distance between the points where it crosses the horizontal axis is equal to the sum of the six horizontal scale characteristic values stored on the card (i.e. numbers corresponding to the distance between points a and g in Figure 4b). This is a simple process and is performed by successively decrementing all elements of the number/distance memory array stored on the card which represents the ridge density graph.

Once the newly acquired graph has been adjusted, the peak value, integral under the curve and the six distances between points on the horizontal axis of the graph are calculated and are then compared with the characteristics encoded on the magnetic stripe of the card with an allowable margin of error, preferably determined by experiment to suit the particular application. If both sets of graphical data match, then the identity of the card bearer has been verified and some audible or visual indication of this fact is given to the user by an indicator 43.

Clearly, the position of the finger when the graph characteristics data was encoded onto the card and the position of the finger of the person being verified may be different, therefore the newly acquired graph will have to be adjusted to line it up with the graph represented by the encoded data.

Figures 6a to 6b show two possible effects on the ridge density graph caused by the finger being displaced vertically compared to the position of the finger at the time when the data was encoded onto the card. In Figures 6a to 7b the recently acquired graph is shown with a broken line and the previously stored graph is shown as a full line.

Figure 6a shows the effect of the finger being

moved so that there is more of the finger above the sensor than at the time of encoding. This graph can still be used to verify the fingerprint. The whole graph is shifted down the vertical axis until the distance between points where it meets the horizontal axis equals the distance between points a and g of Figure 4b as described above.

Figure 6b shows the effect of less of the finger being above the sensor. The graph shown in this case has been shifted down the vertical axis so far that the distance between the points where it meets the horizontal axis is less than the distance between quarter peak value points of the graph data encoded on the card. In some applications it may be determined that there is insufficient data in this case for the stored graph to be used to validate the newly acquired fingerprint. If the vertical displacement of the graph had not reached the point where the horizontal axis crossing points were within the marked bounds then the graph could still be used in most cases.

Figures 7a and 7b show two possible effects on the ridge-density graph caused by the finger being displaced laterally compared to the position at the time when the data was encoded onto the card. The ridge count drops to zero abruptly due to part of the finger being shifted outside the field of the imaging sensor.

The graph shown in Figure 7a can still be used in the verification since the lateral displacement has not affected the shape of the graph above the quarter peak value of the graph encoded on the card and since the distances between horizontal axis points of the graph have been stored on the card as opposed to actual horizontal axis values.

The graph shown in Figure 7b is not suitable for verification in the particular embodiment described since the shape of the graph above the quarter peak value has been affected by the displacement of the finger.

In all cases where the apparatus decides that the newly acquired graph will not be used in the verification process, some kind of warning e.g. audible or visual should be given to the user.

As explained above, the control unit 32 is programmed to accommodate variations in the positioning and orientation of the thumb relative to the sensor 18 during verification and storage steps by manipulation of comparable graphs using standard graph translation techniques. It should also be possible to account for variations in positioning along the length of the thumb by use of data relating to the area under the graph by translating two graphs until their integrals are equal.

The verification apparatus is easy to use and does not require the use of skilled operators. Indeed, the apparatus may be designed for use by the card holder without requiring interaction from staff at the point of sale. The staff need simply note and react appropriately to the signal indicating successful validation or otherwise.

So far, it has been assumed that during the period between the time at which the bearer's fingerprint was encoded onto the magnetic stripe of the card and the time at which the bearer's fingerprint is being verified, the bearer has not damaged his/her fingerprint by, for example, scratching it. In the case of the finger being scratched, the shape of the ridge density graph will be changed.

Figure 8a shows an example of a fingerprint with a grossly exaggerated vertical scratch, and a ridge density graph showing the effect that that scratch would have on the shape of the graph. This situation can be quite easily recognised by control software by looking for a translation of the ridge density graph down the vertical axis between two sensor array line numbers which correspond to the limits of the scratch. The effect on the ridge density graph would be remedied by adjusting

the elements of the array representing the ridge density graph which have been affected by the scratch, extrapolating from the slope of the graph to either side of the trough in the graph to construct a graph shape which would represent the ridge density of the fingerprint without the scratch. Similarly, if at the time that the fingerprint is being encoded onto the card, the finger has such a vertical scratch, the acquired graph would be adjusted in a similar manner to counter the effect of that scratch before the ridge density graph is encoded onto the card.

Figure 8b gives an example of a fingerprint with a grossly exaggerated horizontal scratch and a ridge density graph showing the effect that that scratch would have on the shape of the graph. This situation can be quite easily recognised by control software due to the sharp drop in ridge count at the left hand end of the scratch, scanning the graph from the left to right along with the sharp increase in ridge count corresponding to the right hand end of the scratch. The elements of the array which represent the graph between these two points would be adjusted to counter the effect of the scratch. Similarly, if at the time when the graph representation is being encoded onto the card, such a scratch is recognised, then the graph would be adjusted before its representation is encoded onto the card.

Scratches which are not in either the horizontal or vertical planes would have an effect on the shape of the graph which is a mixture of the cases shown in Figures 8a and 8b and would be countered by performing adjustments of both cases given above.

It should be noted that unless the scratch is fairly substantial, the effect that it has on the ridge density graph will be minimal.

Both the encoder and the verification units can be constructed on a single circuit board which will also hold the microprocessor control unit, imaging sensor with

associated timing and drive circuits and the interface circuits required for the magnetic strip reader/encoder. The units may be housed in a single casing with just the glass plate 20 on which the finger will be placed, a reader/encoder slot through which the card will be passed and a form of pass/fail indicator 43 externally visible. Each unit will normally be in an inactive state and could be activated by the plastic card being passed through the reader/encoder slot at which stage a verification of the bearer's fingerprint will be made.

Figures 9a, 9b and 9c show one form of sensing unit which includes means for mechanically registering a finger whose print is to be sensed, in order to align as far as is possible fingerprint data obtained during verification with that obtained during encoding, so as to reduce the amount of software manipulation of the graph data.

Figures 9a and 9b are a side and end view respectively of a sensing apparatus with mechanical registration and show the support 20 for the glass focusing plate 12 (12 in Figure 1 and 22 in Figure 5). A finger receiving member 50 has a fingertip receiving notch 54 (Figure 9c) against which a fingertip is placed with the finger over the glass plate 12. The fingertip receiving member 50 is T shaped in end view (Figure 9b) and is slidably mounted with respect to the support 20 by grooves 56 formed in the sides of the member receiving angled pieces 58 screwed to the support 20 for the glass plate 12. It will be appreciated that any sliding arrangement will suffice. The apparatus also includes an abutment support 60 carrying a spring 62 and a microswitch 64. The fingertip receiving member carries an actuator 66 for the microswitch 64. In use, the fingertip receiving member 50 is pushed, against the action of spring 62 in its final stages, by a fingertip until the actuator 66 activates the microswitch 64 to indicate alignment and trigger commencement of scanning

by the sensor array (Figure 1). Although it is not shown in the drawings, a heat sensor could be provided for alignment of the finger in a horizontal sense (across the finger), to actuate the unit on sensing heat from the finger to a certain level.

One application is to check identity at entrances into areas such as football grounds. In this way, the identity of previously known vandals would be indicated by comparison with previously stored data, and access denied. Alternatively, positive verification, for example on the production of magnetic stripe cards from club members, could be carried out.

The invention has been described above in relation to encoding data onto magnetic stripe cards. Of course, the encoding step has a far wider application. For example, it would be possible, where the system is to be used for security in a building such as a hotel to store the ridge density graphical data in its entirety in a central computer. Each authorised person could then be issued with a card merely carrying information relating to a memory location in the central computer. The sensing unit could then transmit, during verification, the complete set of graphic data obtained for a full comparison within the central computer with the data stored at that memory location. This embodiment effectively involves the transfer of the comparison step from a microprocessor at the sensing unit to a larger computer.

Embodiments of the invention are also applicable at passport control centres, where fingerprint information provides fuller evidence that the bearer of the passport is truly authorised.

Another application is for the currently used so-called "credit card" safes such as that manufactured under the trade name "Panther minisafe", which are operated with standard credit cards. Such safes can only be opened using the magnetic stripe card with which they were closed, and the fingerprint verification technique would provide extra security here.

CLAIMS:

1. A method of obtaining information from a fingerprint characterised by deriving from an area of the fingerprint data relating to the number of ridges (or troughs), orthogonal to a line across the area, at each of a plurality of positions along the line.

2. A method as claimed in claim 1, in which the number of ridges (or troughs) in a direction lengthwise of the fingerprint is derived at a plurality of positions across the fingerprint.

3. A method as claimed in claim 1 or 2 in which the number of ridges (or troughs) in a direction across the fingerprint is derived with respect to a plurality of positions lengthwise of the fingerprint.

4. A method as claimed in any preceding claim characterised by using a sensing device to produce, for each of the plurality of positions, a signal related in magnitude to the arrangement of ridges and troughs orthogonal to that line; comparing, for each position, the signal so produced with a reference value to obtain a signal for that position which varies between two values; counting the number of changes between the two values in the signal so obtained to derive a count of the number of ridges (or troughs) corresponding to that position.

5. A method as claimed in claim 4, wherein the sensing device comprises a two-dimensional array of sensing regions.

6. A method according to any preceding claim in which the data is derived as an ordered set of values.

7. A method as claimed in claim 6 in which one or more of the following items of data is derived:

a) the maximum number of ridges (or troughs) and the position where it occurs;

b) the number of ridges (or troughs) corresponding to selected fractions (such as one quarter, one half or three quarters) of the maximum number and the

position where they occur;

c) the distance between the positions referred to in a) and b);

d) the area under a graphical representation of the data as ridge (or trough) number against position;

e) the number and position at selected coordinate points of such a graphical representation.

8. A method of verifying a person's identity characterised by: deriving data from that person's fingerprint in accordance with the method of any preceding claim; comparing such data with similarly derived and previously stored data from the fingerprint to be compared; and indicating the result of the comparison step.

9. Apparatus for obtaining information from a fingerprint characterised by:

means for deriving, from an area of the fingerprint, data relating to the number of ridges (or troughs), orthogonal to a line across the area, at each of a plurality of positions along the line.

10. Apparatus as claimed in claim 9, wherein said means comprises: an image sensing device capable of producing for each position of the area a signal related in magnitude to the arrangement of ridges and troughs orthogonal to that line; means for comparing for each position the signal so produced with a reference value to obtain a signal for that position which varies between two values; and a counter for counting the number of changes between the two values in that signal to derive a count of the number of ridges (or troughs) corresponding to that position.

11. Apparatus as claimed in claim 10, wherein the sensing device comprises a two-dimensional array of sensing regions.

12. Apparatus as claimed in claim 9, 10 or 11 including means for deriving said data as an ordered set of values of ridge (or trough) count with respect to

position.

13. Apparatus as claimed in any of claims 9 to 12 which includes processing means for processing the derived data to produce items of data, said items being one or more of the following:

a) the maximum number of ridges (or troughs) and the position where it occurs;

b) the number of ridges (or troughs) corresponding to selected fractions (such as one quarter, one half or three quarters) of the maximum number and the position where they occur;

c) the distance between the positions referred to in a) or b);

d) the area under a graphical representation of the data as ridge (or trough) number against position;

e) the number and position at selected coordinate points of such a graphical representation.

14. Apparatus as claimed in any of claims 9 to 13, for verifying the identity of a person, which includes: means for comparing data so derived from a fingerprint of that person with data, similarly derived and previously stored, of the fingerprint to be compared; and means for indicating the result of the comparison.

15. Apparatus as claimed in claims 13 and 14, in which the processing means is capable of transforming two sets of such values representing respectively data derived from a fingerprint of a person whose identity is to be verified and previously stored data for comparison one with the other when the derived data and stored data do not correspond due to differences in the area of the fingerprints from which the data is derived.

16. Apparatus as claimed in any of claims 8 to 13 which includes means for mechanically registering a fingerpad, whose fingerprint is to be sensed, with an image sensing device of the apparatus.

1/4

Fig.1.

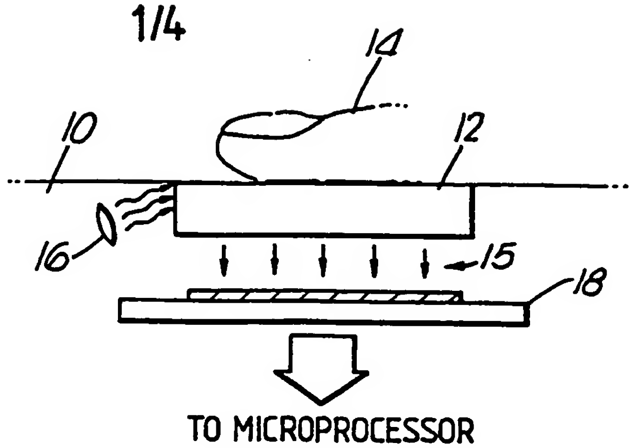
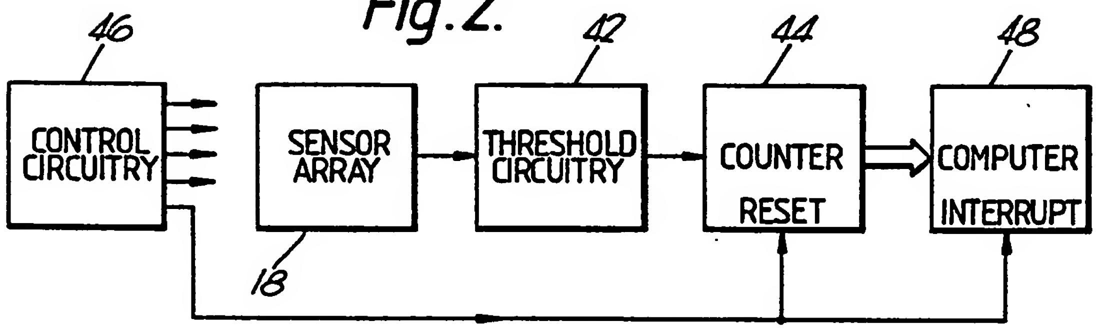


Fig.2.



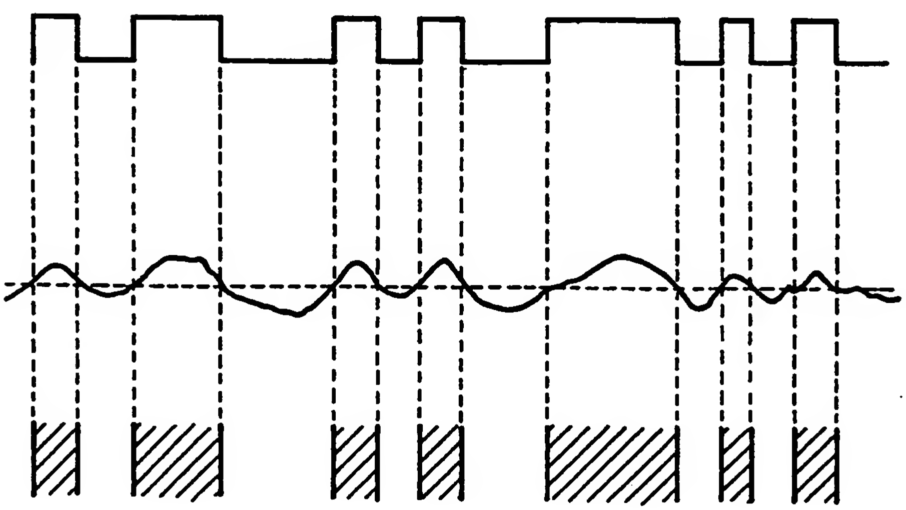


Fig.3c.

Fig.3b.

Fig.3a.

Fig. 4a.

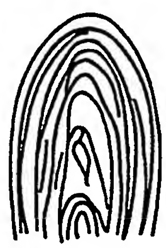


Fig. 4b.

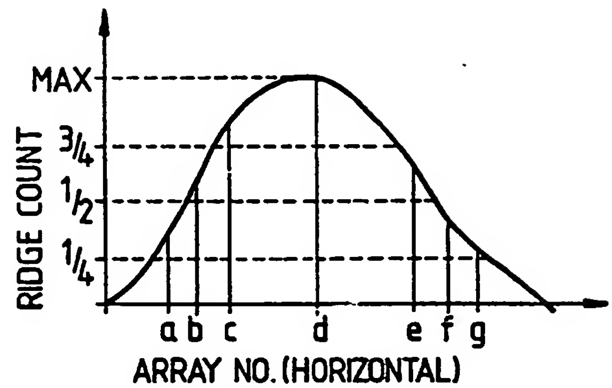


Fig. 4c.

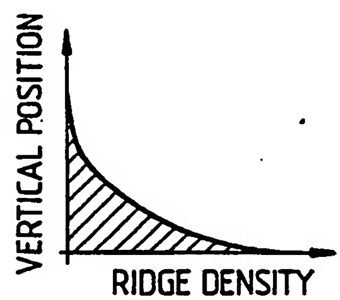


Fig. 5.

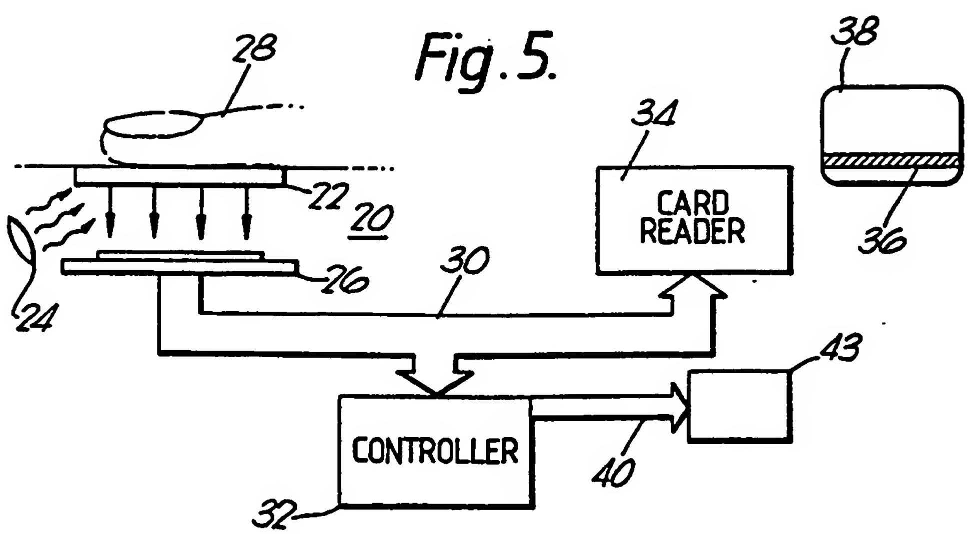


Fig.6a.

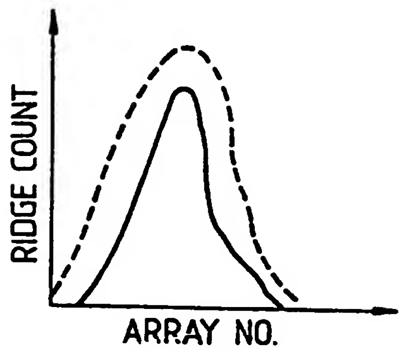


Fig.6b.

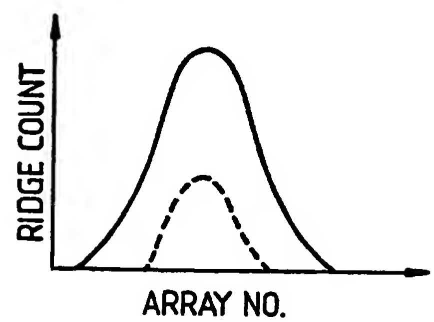


Fig.7a.

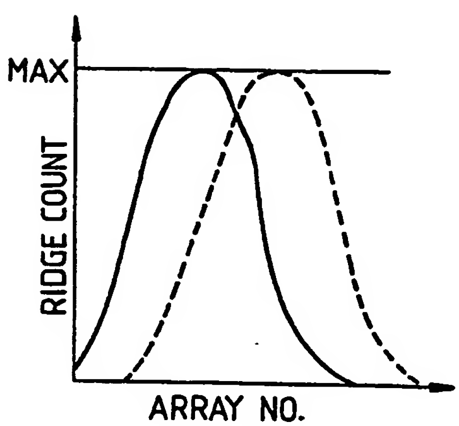


Fig.7b.

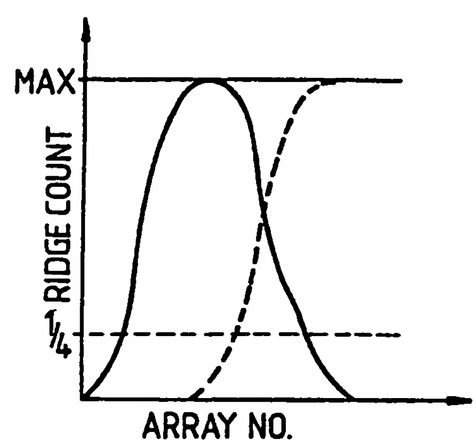


Fig.8a.

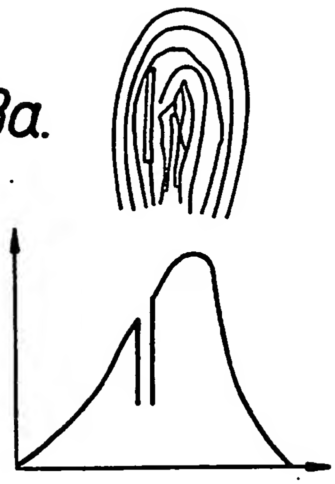


Fig.8b.

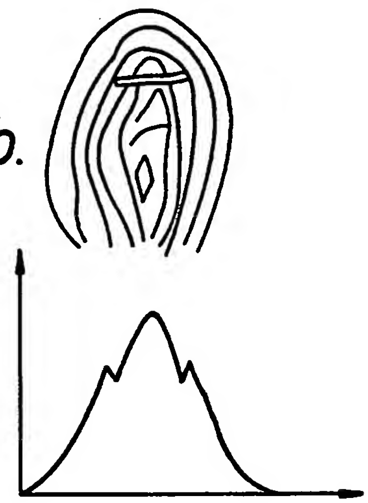
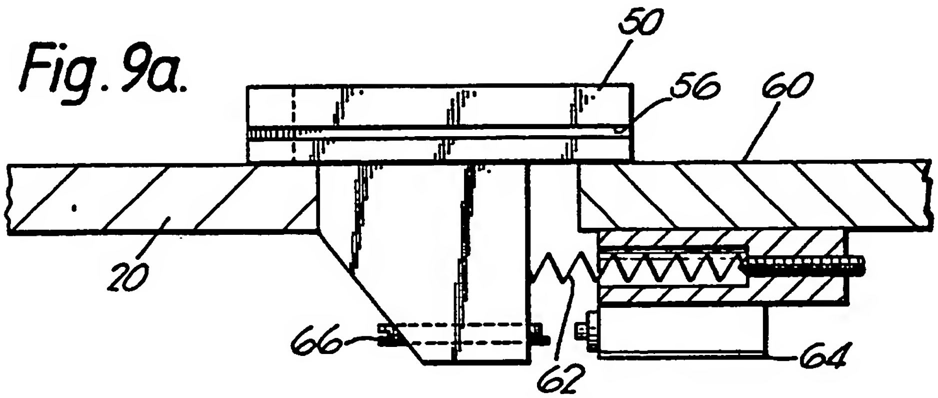


Fig.9a.



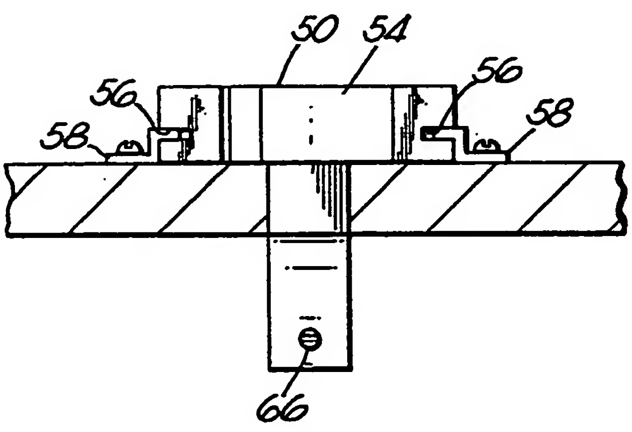


Fig.9b.

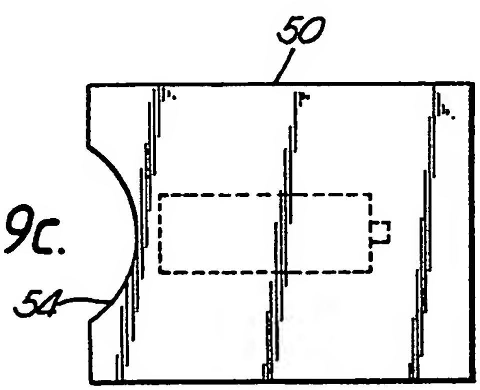


Fig.9c.

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 87/00262

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC^4: G 07 C 9/00

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC^4	G 07 C; A 61 B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [*]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	EP, A, 0169496 (NEC) 29 January 1986 see abstract; page 2, line 23 - page 3, line 18; page 6, line 11 - page 10, line 4; page 11, line 1 - page 12, line 25; figures	1,9
A		2-8,10-14
	--	
X	EP, A, 0159037 (NEC) 23 October 1985 see abstract; page 2, line 13 - page 3, line 6; page 8, line 12 - page 10, line 26; figures	1,8,9
A		4,5,7,10-12,14,15
	--	
X	GB, A, 2050026 (NEC) 31 December 1980 see abstract; page 1, lines 43-103; page 2, line 89 - page 3, line 61; claims; figures	1,9
A		4-8,11-13
	--	
X	IBM Technical Disclosure Bulletin, volume 18, no. 3, August 1975, (New York, US), ./.	

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
10th July 1987	-5 AUG 1987
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	M. VAN MOL

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
	W.J. Deerhake et al.: "Fingerprint verification method", pages 888,889 see the whole document --	1,9
A	US, A, 4246568 (PETERSON) 20 January 1981 see column 2, line 14 - column 3, line 43; figures --	1,4-11,14, 15
A	US, A, 4186378 (MOULTON) 29 January 1980 see column 1, line 40 - column 2, line 32; claims; figures --	1,4-6,8-11, 14
A	WO, A, 82/03286 (LÖFBERG) 30 September 1982 see abstract; page 5, line 23 - page 7, line 16; page 10, line 8 - page 11, line 8; page 12, line 20 - page 16, line 16; figures cited in the application	1,4-6,8-10, 14

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON

INTERNATIONAL APPLICATION NO. PCT/GB 87/00262 (SA 16950)

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 20/07/87

The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A- 0169496	29/01/86	JP-A- 61043379	01/03/86
		JP-A- 61043380	01/03/86
		JP-A- 61043381	01/03/86
		JP-A- 61059574	27/03/86
		JP-A- 61059580	27/03/86
		JP-A- 61028175	07/02/86
		US-A- 4663211	05/05/87
EP-A- 0159037	23/10/85	JP-A- 60221879	06/11/85
		JP-A- 60221880	06/11/85
		JP-A- 60221881	06/11/85
		JP-A- 60221882	06/11/85
		JP-A- 60221883	06/11/85
GB-A- 2050026	31/12/80	JP-A- 55138174	28/10/80
		US-A- 4310827	12/01/82
US-A- 4246568	20/01/81	None	
US-A- 4186378	29/01/80	NL-A- 7806835	23/01/79
		FR-A,B 2398351	16/02/79
		DE-A,C 2831582	01/02/79
		JP-A- 54052428	25/04/79
		GB-A- 1601987	04/11/81
		CA-A- 1121914	13/04/82
WO-A- 8203286	30/09/82	SE-A- 8101707	19/09/82
		SE-B- 425704	25/10/82
		AU-A- 8273682	06/10/82
		EP-A,B 0085680	17/08/83
		US-A- 4582985	15/04/86

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82